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AIP Pub. No. R-151.27

June 1990

ENROLLMENTS AND DEGREES

The arrival of a new decade presents the opportunity to review some of the problems anticipated for it during the previous decade and re-evaluate their severity. Two problems, causing major concern for the academic physics community, deal with the possible effects of a declining college-age population, and with the consequences of a potential increase in retirements, as a result of which, large numbers of physicists may need to be replaced by the end of the 1990s.

Since both problems are related to the education pipeline, a thorough analysis of its components could form a basis for finding solutions. Since 1960, such analyses were carried out as part of the annual survey of Enrollments and Degrees and they have provided comprehensive reliable data on physics students and degree recipients from freshman enrollments to the fluctuating PhD production. By focusing on data that describe the most recent ten-year period, we were able to determine that the declining college-age population has not yet had any marked effect on undergraduate physics majors. This conclusion is based on an examination of the enrollment totals discussed in more detail in connection with **Figure II**.

Table I indicates how many degree-granting physics programs there are in the United States; it classifies them by highest degree and identifies in its footnote the five institutions that have two physics doctorate-granting departments.

Table I. Institutions by highest physics degree offered, 1985–1990.

Academic year	Doctoral-granting*	Master's-granting	Bachelor's-granting
1985–86	168	91	485
1986–87	168	90	496
1987–88	169	90	498
1988–89	169	89	496
1989–90	171	85	497

**Five of these institutions have two physics doctorate-granting departments. They are Stanford U., U. of CA-Davis, Yale U., Harvard U. and Cornell U.*

To address the problem of vacancies that will be created by highly trained physicists who retire, we need to examine the other end of the pipeline and focus on physics education at the graduate level. From its rising enrollment trends we can try to project the extent to which future demands will be met. The second part of **Figure I** indicates the gradual rise in PhD production since 1982. This figure also identifies two types of master's degrees: the terminal master's degrees and those granted enroute to higher physics degrees.

Figure I. Physics degrees awarded by academic year, 1978–1989.

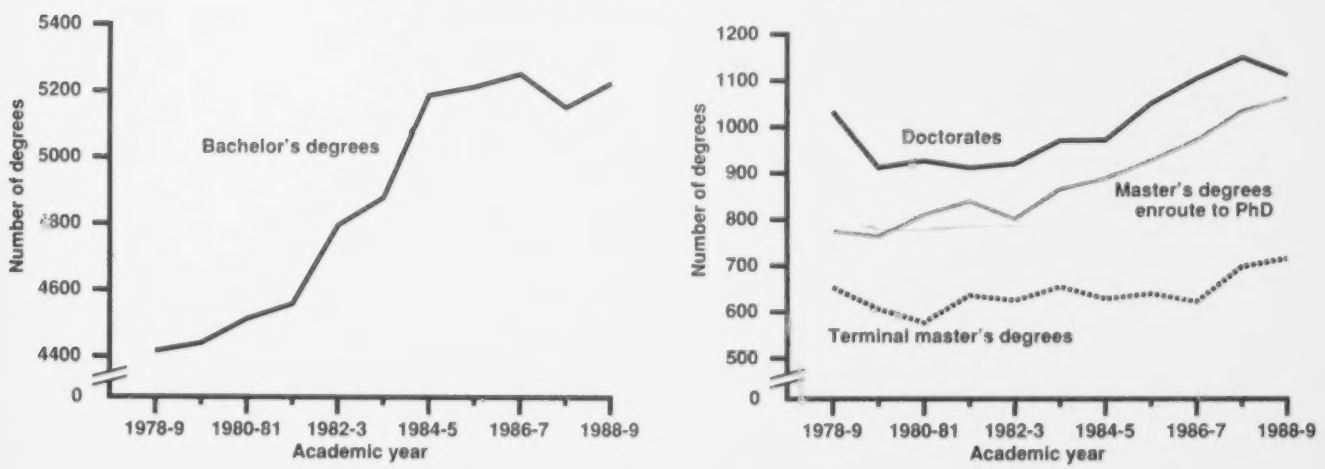

Table II. Physics enrollments and degrees awarded by academic year, 1978–1990.

Academic year	Number of physics degrees granted (July 1 to June 30)			Undergraduate physics major enrollments		Graduate physics student enrollments*	
	Bachelor's	Master's	Doctor's	Juniors	Seniors	Total	1st year
1978–79	4416	1428	1033	5835	4964	9 813	2458
1979–80	4440	1370	912	5696	4942	9 647	2439
1980–81	4513	1387	927	5905	5091	9 934	2564
1981–82	4558	1476	912	6386	5372	10 173	2637
1982–83	4795	1426	921	6299	5580	10 429	2630
1983–84	4878	1521	971	6303	5658	10 922	2855
1984–85	5188	1518	972	6601	6009	11 337	2863
1985–86	5214	1589	1051	6689	6092	12 011	2981
1986–87	5253	1596	1105	6592	6119	12 616	3162
1987–88	5152	1733	1150	6412	5959	13 143	3274
1988–89	5226	1781	1112	6390	5914	13 361	3132
1989–90				6313	5896	13 708	3059

**Includes part-time students.*

The numerical data for both parts of **Figure I** are presented as part of **Table II** which also includes undergraduate and graduate physics enrollments. Although curricula differ widely among the 750 undergraduate physics programs, the great majority of schools expect their students to have completed the necessary prerequisites by the time they reach their junior year to declare their majors. Thus, examining the numbers of juniors since 1985-86 a gradual but distinctly declining trend becomes evident. The total graduate enrollment, on the other hand, continues to increase for the tenth consecutive year.

Table III. Undergraduate and graduate enrollments and degrees by institution type, 1978–1990.

Academic year	Number of physics degrees granted (July 1 to June 30)			Undergraduate physics-major enrollments		Graduate physics student enrollments*	
	Bachelor's	Master's	Doctor's	Juniors	Seniors	Total	1st year
Doctoral-granting institutions							
1978–79	2158	1183	1033	2937	2579	8 864	2107
1979–80	2142	1151	912	2696	2491	8 744	2072
1980–81	2123	1161	927	2765	2568	9 062	2223
1981–82	2179	1281	912	2996	2671	9 273	2275
1982–83	2192	1210	921	2962	2645	9 524	2288
1983–84	2195	1319	971	2955	2824	10 006	2495
1984–85	2460	1286	972	3059	3105	10 357	2443
1985–86	2377	1358	1051	3120	2961	10 937	2574
1986–87	2473	1357	1105	3132	3148	11 389	2667
1987–88	2460	1432	1150	3030	2991	11 880	2737
1988–89	2526	1465	1112	3018	2972	12 069	2638
1989–90				2877	2993	12 440	2623
Master's-granting institutions							
1978–79	541	245		795	694	949	351
1979–80	585	219		705	650	903	367
1980–81	589	226		868	655	872	341
1981–82	532	195		917	734	900	362
1982–83	554	216		877	752	905	342
1983–84	610	202		830	722	916	360
1984–85	658	232		974	781	980	420
1985–86	632	231		1014	865	1 074	407
1986–87	660	239		913	791	1 227	495
1987–88	591	301		871	750	1 263	537
1988–89	582	316		822	795	1 292	494
1989–90				773	737	1 268	436
Bachelor's-granting institutions							
1978–79	1717			2103	1691		
1979–80	1713			2295	1801		
1980–81	1801			2272	1868		
1981–82	1847			2473	1967		
1982–83	2049			2460	2183		
1983–84	2073			2518	2112		
1984–85	2070			2568	2123		
1985–86	2205			2555	2266		
1986–87	2120			2547	2180		
1987–88	2101			2511	2218		
1988–89	2118			2550	2147		
1989–90				2663	2166		

**Includes part-time students.*

Table IV. Number of students enrolling in their first college/university physics course in 1989–90.

Discipline of potential majors	Institution type: Bachelor's-granting N		Master's-granting N		Doctoral-granting N		Total N		N
Type of course	Calculus-based	Algebra-based	Calculus-based	Algebra-based	Calculus-based	Algebra-based	Calculus-based	Algebra-based	Total intro.
Engineering majors	16 500	2 000	10 700	1 100	53 300	5 200	80 500	8 300	88 800
Physical sciences majors*	10 900	5 300	4 000	3 100	21 000	8 800	35 900	17 200	53 100
Biology, health-related majors	4 500	17 000	850	10 000	10 700	28 500	16 050	55 500	71 550
Other, incl. major not yet declared	4 000	17 500	950	11 500	6 300	41 600	11 250	70 600	81 850
	35 900	41 800	16 500	25 700	91 300	84 100	143 700	151 600	
Total introductory enrollment N	77 700		42 200		175 400				295 300
%	26.3		14.3		59.4				100%

**Includes physics, chemistry, mathematics, etc.*
Note: The format of the question asking for introductory enrollments has been changed so as to include single-semester algebra-based courses.

To illustrate how unevenly physics students are distributed among the three types of institutions (defined in **Table I**), we present an expanded version of **Table II** in the form of **Table III**. Here we find that approximately half of the undergraduate physics majors are enrolled at the doctorate-granting institutions which collectively comprise less than one-quarter of all institutions that grant physics bachelor's degrees. Should shifts in enrollments or degree production occur among the types of institutions, they can readily be identified from the format of **Table III**.

Introductory physics enrollment

In order to attract a more diversified group of students into the introductory physics courses, most of the physics departments offer both algebra-based and calculus-based courses. A third type of introductory physics course offered by a few physics departments has no prerequisite at all; enrollments in those courses were included with the algebra-based courses in **Table IV**. The question that prompted these enrollment totals asked for the number of students who enrolled in their first college/university physics course in 1989-90. When dividing the collective total of 300,000 students according to their intended majors, we find that the split between enrolling in calculus-based or algebra-based courses forms a 10:1 ratio for the engineering majors, a 2:1 ratio for those interested in a hard science or mathematics and a 1:3 ratio for the life science or health profession majors. The fourth category, referring to "other" majors, include technology and architecture majors for whom an introductory physics course will be required, but a majority of those 82,000 students will eventually choose one of the three majors listed in **Table IV**.

Undergraduate physics majors

With a greater emphasis on required courses in recent years, the decision to major in physics needs to be made close to the freshman year. Consequently chairpersons, who monitor the enrollments in lower level physics courses, can provide fairly reliable estimates of their prospective physics majors at the freshman and sophomore levels. From the early 1980s on, each fall those estimates ranged from eight to nine thousand freshmen who were sufficiently motivated to express their intentions to major in physics. Traditionally, two-thirds of each class of freshman physics majors sustain their interest in the subject matter over a four-year period while they derive additional encouragement from either the research atmospheres offered at 171 large universities, (see **Table I**) or the intimate environments created by some of the 497 four-year colleges. The resulting annual production of physics bachelors is presented in the first part of **Figure I**.

We present four graduating classes in **Figure II**, starting with the class of 1990 for which we have firm data. This class shows a 31% attrition between the 8584 freshmen, estimated by the

Figure II. Actual and projected number of undergraduate physics majors.

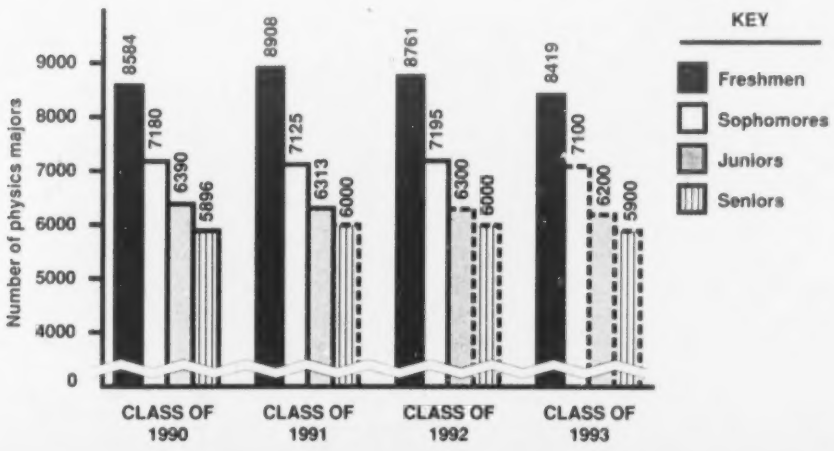

Table V. Attrition of undergraduate physics majors by type of institution, 1976–77 to 1988–89.

	Doctoral-granting institution		Master's-granting institution		Bachelor's-granting institution	
Graduating class	No. of freshmen	% reaching sr. year	No. of freshmen	% reaching sr. year	No. of freshmen	% reaching sr. year
1980	3400	74%	1110	60%	3200	56%
1981	3450	73	1070	63	3310	57
1982	3520	73	1140	63	3410	59
1983	3590	72	1160	63	3510	60
1984	3770	74	1250	60	3550	60
1985	3890	75	1160	68	3560	60
1986	3940	78	1170	69	3570	61
1987	3930	77	1120	71	3590	61
1988	3890	76	1125	71	3585	60
1989	3850	77	1130	70	3670	59

Note: Number of freshmen are based on 3-year averages.

chairpersons in the fall of 1986, and the 5896 seniors recorded for the academic year 1989-90. For a larger number of freshmen the attrition tends to be higher because the estimates invariably include some less serious students. Thus we project a 33% attrition for the class of 1991 because in the fall of 1987 chairpersons reported the highest estimates of freshmen ever recorded. If 32% and 30% were the attrition rates for the classes of 1992 and 1993 respectively, we expect 6000 and 5900 physics majors to reach senior status for those two graduating classes.

Having illustrated the differences that exist among the three types of institutions, it should come as no surprise to find differing attrition rates among their respective undergraduate physics majors. An illustration of this occurrence can be found in **Table V**, which indicates what proportion of freshmen reach senior status at each of the three types of institutions. For example, PhD-granting institutions appear to have the highest retention rates where three out of four freshmen remain physics majors into the senior year. The lowest retention rate was consistently recorded for the four-year colleges where only 60% reached senior status. The master's institutions, with the smallest enrollment of physics majors, showed the greatest change in retention rates over a ten-year period. Only 60% of the 1110 freshmen in 1976-77 reached senior status in 1979-80; nine years later, in 1985-86, the total number of freshmen hardly changed (1130) but the proportion reaching senior status had increased to 70% for that type of institution.

A variety of undergraduate physics programs can be found in all regions of the United States, as indicated by their geographic distribution presented in **Table VI**. Since half of the physics majors are interested in immediate employment rather than graduate school, a rising number of undergraduates extend their senior status over more than one year in order to acquire some experience with the job market. This group, which more than doubled in the last ten years, is presented in the right-hand column of **Table VI** under the heading "Fifth-year undergraduates." The lower portion of this table presents the enrollments by type of institution from which the trend data of **Table V** were calculated.

Table VI. Undergraduate physics majors by geographic region and type of institution, 1989–90.

Geographic region*	Estimated** no. of freshmen	Estimated** no. of sophomores	Number of juniors	Number of seniors	Fifth-year undergraduates
New England	669	578	555	483	31
Mid Atlantic	1380	1173	1008	888	108
E. N. Central	1355	1135	997	907	208
W. N. Central	745	647	555	472	99
S. Atlantic	1297	1136	929	783	161
E. S. Central	359	315	287	220	33
W. S. Central	722	604	536	499	136
Mountain	586	512	451	512	138
Pacific	1306	1095	995	1132	312
Total	8419	7195	6313	5896	1226
Doctoral-granting inst.	3677	3215	2877	2993	671
Master's-granting inst.	966	890	773	737	230
Bachelor's-granting inst.	3776	3090	2663	2166	325

** New England—CT, ME, MA, NH, RI, VT; Middle Atlantic—NJ, NY, PA; East North Central—IL, IN, MI, OH, WI; West North Central—IA, KS, MN, MO, NE, ND, SD; South Atlantic—DE, DC, FL, GA, MD, NC, SC, VA, WV; East South Central—AL, KY, MS, TN; West South Central—AR, LA, OK, TX; Mountain—AZ, CO, ID, MT, NV, NM, UT, WY; Pacific—AK, CA, HI, OR, WA.*

***Estimates of potential physics majors are made by the physics department chairpersons.*

Table VII. Trend in entering U.S. and foreign graduate physics students, 1980–1990.

Academic year	No. of first-year graduate students U.S.	Foreign	Total	% foreign students of total
1980–81	1720	844	2564	32.9
1981–82	1654	983	2637	37.3
1982–83	1576	1054	2630	40.1
1983–84	1763	1092	2855	38.2
1984–85	1747	1116	2863	39.0
1985–86	1721	1260	2981	42.3
1986–87	1799	1363	3162	43.1
1987–88	1944	1330	3274	40.6
1988–89	1825	1307	3132	41.7
1989–90	1724	1335	3059	43.6

Graduate enrollment

Concern over meeting the demand for U.S. physicists in the 1990s can be substantiated by looking at the last three rows of the trend data presented in **Table VII**. It seems that despite the major recruiting efforts of graduate physics departments, the number of U.S. citizens who enroll as first-year graduate physics students is declining again. **Table VII** takes us back to 1980 when foreign students comprised one-third of the new graduate physics students; by 1990, the new foreign graduate students have reached an all-time high of 43.6%.

For a more detailed look at the graduate enrollment, we focus on the study status and citizenship of all level graduate physics students at the two types of institutions. **Table VIII** indicates that the master's institutions enroll only 10% of the graduate physics students but the composition of that student body has undergone major changes during the past decade. An important function of those institutions continues to be that of providing limited graduate training in late afternoon or evening programs to part-time students who are full-time employees of industrial companies in their geographic areas. Although the number of those part-time students has not changed significantly since 1980, the proportion they comprise of the total enrollment at that type of institution, declined from one-half to one-third. The increase in foreign students, almost all of whom study on a full-time basis, accounts for that change.

Table VIII. Full-time, part-time, and foreign graduate physics enrollment by type of institution, 1980–1990.

	Graduate students at doctoral-granting institutions					Graduate students at master's-granting institutions				
Academic year	Full-time	Part-time	Foreign	% foreign of total	Total	Full-time	Part-time	Foreign	% foreign of total	Total
1980–81	8 302	760	2540	28.0	9 062	484	388	163	18.7	872
1981–82	8 555	718	2894	31.2	9 273	543	357	213	23.7	900
1982–83	8 712	812	3193	33.5	9 524	566	339	221	24.4	905
1983–84	9 285	721	3433	34.3	10 006	569	347	254	27.7	916
1984–85	9 647	710	3811	36.8	10 357	604	376	293	29.9	980
1985–86	10 119	818	4259	38.9	10 937	620	454	306	28.5	1074
1986–87	10 538	851	4519	39.7	11 389	772	455	397	32.4	1227
1987–88	11 015	865	4813	40.5	11 880	797	466	448	35.5	1263
1988–89	11 182	887	5049	41.8	12 069	830	462	471	36.5	1292
1989–90	11 643	797	5328	42.8	12 440	839	429	454	35.8	1268

Table IX. Regional distribution of U.S. and foreign teaching assistants by type of institution, 1989–90.

Geographic region*		Doctoral-granting institutions		Master's-granting institutions	
		Total no. of TA's	Total no. of foreign TA's	Total no. of TA's	Total no. of foreign TA's
New England		508	250	27	17
Mid Atlantic		767	471	22	8
E. N. Central		775	325	177	115
W. N. Central		275	153	55	24
S. Atlantic		595	265	74	26
E. S. Central		163	95	43	21
W. S. Central		449	282	50	24
Mountain		356	183	6	3
Pacific		680	233	69	19
Total	N	4568	2257	523	257
	%		49.4%		49.1%

** New England—CT, ME, MA, NH, RI, VT; Middle Atlantic—NJ, NY, PA; East North Central—IL, IN, MI, OH, WI; West North Central—IA, KS, MN, MO, NE, ND, SD; South Atlantic—DE, DC, FL, GA, MD, NC, SC, VA, WV; East South Central—AL, KY, MS, TN; West South Central—AR, LA, OK, TX; Mountain—AZ, CO, ID, MT, NV, NM, UT, WY; Pacific—AK, CA, HI, OR, WA.*

The visas with which foreign students enter the United States make them ineligible for off-campus employment; since very few of them receive support from their native countries, they compete with U.S. students for the available teaching assistantships offered at the institutions that enroll them. **Table IX** shows the geographic distribution of 5091 teaching assistantships and also shows that almost half of them are held by foreign graduate students.

Degrees granted

As we encounter more diversified educational backgrounds among the doctoral candidates, it becomes more difficult to project the number of degree recipients for future years. For example, up until this year we found a high correlation between the first-year graduate students at PhD-granting institutions and the number of doctorates granted five years later. But this formula does not take into account the increase in the number of foreign students who begin their graduate studies at master's institutions (see **Table VIII**) and subsequently transfer into doctoral programs. An altered pattern of this type may change the median number of years of graduate study that students need to complete their physics doctorates and may call for an adjustment in our projection method. The last point of actual data in **Figure III** reflects a 3% decline in the number of doctorates granted between 1988 and 1989. But for the next three years we project consecutive increases up to a total of 1260 PhDs in 1992, and a subsequent decline to 1200 physics doctorates to be conferred in 1994.

Figure III. Actual and projected number of physics doctorates granted, 1979-1994.

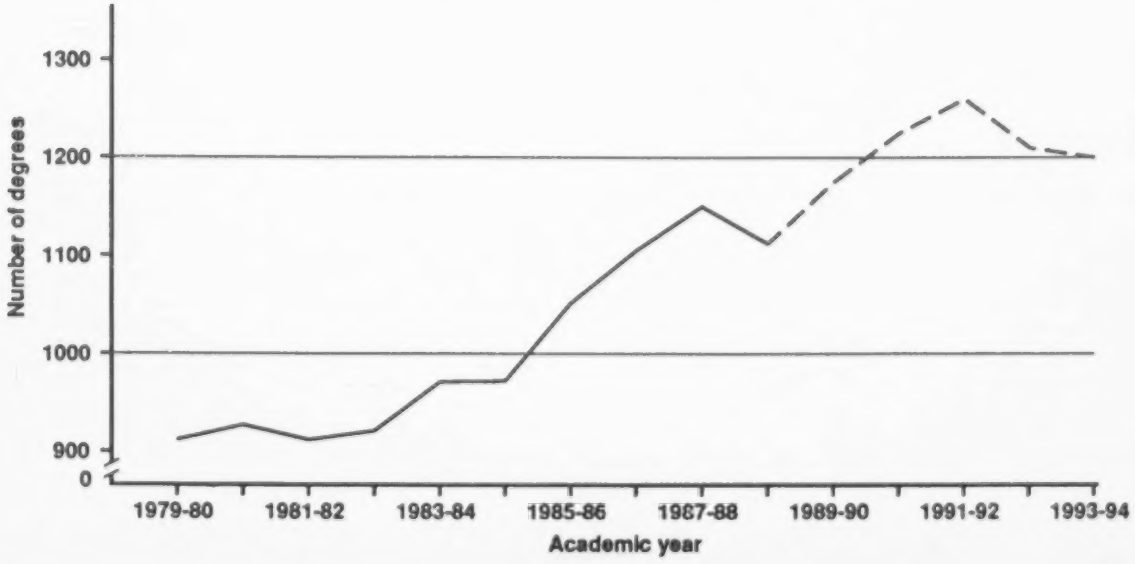

Table X. Physics degrees by type of institution and geographic region, 1988–89.**

Geographic region*	Bachelor's degrees			Master's degree		Terminal master's degrees		Doctorates
	Institution type			Institution type		Institution type		Institution type
	I	II	III	II	III	II	III	III
New England	149	12	329	13	111	8	62	138
Mid Atlantic	432	51	467	9	192	3	72	216
E. N. Central	316	130	328	46	164	49	102	211
W. N. Central	262	52	141	18	26	14	34	50
S. Atlantic	336	81	307	18	84	19	67	122
E. S. Central	108	47	57	13	37	4	19	24
W. S. Central	151	54	130	17	61	27	34	76
Mountain	90	12	262	0	67	7	36	74
Pacific	306	117	499	14	210	37	87	201
Subtotal	2150	556	2520	148	952	168	513	1112
Subtotal				1100		681		
Total		5226			1781			1112

See Table IX for explanation of geographic region.

***Institution type indicates the highest physics degree offered; type I = Bachelor's degree, type II = Master's degree, type III = Doctorate.*

The four types of degrees shown in **Figure I** and granted by three types of institutions are presented in considerable detail for the year 1988-89 in **Table X**. For example, this table presents a geographic distribution of 148 students who need to transfer from master's institutions in order to pursue doctoral studies. Although the master's institutions grant more terminal master's degrees than those granted enroute to a physics doctorate, it is the PhD-granting institutions that continue to grant three out of every four terminal master's degrees.

To make the information on minority groups more meaningful than in previous years, we have asked the physics departments that supply these data to single out the U.S. citizens from each group of degree recipients. We define minority groups as those who have a small but notable representation among the physics graduates, a definition that clearly applies to women who are granted physics degrees. **Table XI** continues to identify six specific minority groups, not including women, but its new format readily yields statistics such as: The proportion of physics doctorates granted to members of U.S. minority groups is 6%.

Table XI. Number of physics degrees granted by sex, citizenship and minority group* status, 1988–89.

Type of degrees	Sex	Total no. of degrees	Black		Native American Indian	Hispanic		Oriental		Asian Indian		Arab	
			U.S.	Foreign		U.S.	Foreign	U.S.	Foreign	U.S.	Foreign	U.S.	Foreign
Bachelor's	Men	4390	133	12	3	46	14	143	52	29	30	20	29
	Women	836	20	–	2	9	3	27	17	5	5	2	2
	Total	5226	153	12	5	55	17	170	69	34	35	22	31
Master's enroute	Men	939	18	7	–	6	13	27	212	6	57	–	17
	Women	161	1	–	–	1	5	4	51	1	16	–	2
	Total	1100	19	7	–	7	18	31	263	7	73	–	19
Terminal master's	Men	571	16	5	1	2	9	8	53	–	20	2	14
	Women	110	1	1	–	–	3	3	13	–	17	–	3
	Total	681	17	6	1	2	12	11	66	–	37	2	17
Doctor's	Men	1021	8	6	1	7	21	30	218	4	55	5	28
	Women	91	1	1	1	2	3	5	19	2	8	–	1
	Total	1112	9	7	2	9	24	35	237	6	63	5	29

**Minorities in AIP surveys are defined as groups with a low representation in the physics community, but one whose participation has aroused considerable interest.*

ASTRONOMY

Table XII. Trend in astronomy enrollments and degrees, 1980–1990.

Academic year	No. of astronomy degrees granted (July 1 to June 30)				Undergraduate* astronomy major enrollments		Graduate astronomy enrollments*	
	Bachelor's	Master's enroute	Terminal master's	Doctor's	Juniors	Seniors	Total	1st year
1980–81	156	34	24	82	275	238	686	164
1981–82	181	54	15	70	252	224	647	142
1982–83	138	61	22	81	274	232	670	178
1983–84	137	51	22	74	242	217	688	154
1984–85	145	56	16	66	239	212	716	151
1985–86	169	61	24	86	232	252	711	170
1986–87	172	38	23	72	268	255	755	173
1987–88	181	51	24	94	250	285	731	171
1988–89	196	77	16	94	213	275	780	169
1989–90					223	200	842	186

**Includes part-time students.*

In the mid 1970s, this annual survey of Enrollments and Degrees was expanded to include 64 degree-granting astronomy departments, 24 of which are departments where physics and astronomy are combined. **Table XII** presents the trend data reported by all the astronomy departments and clearly points to steady increases in the number of bachelor's degrees granted since 1983. Also, the most recent graduate enrollment totals are the highest recorded since 1980. The drop in the number of seniors for 1989-90 reflects a change on the questionnaire. A parallel situation to that of the physics majors exists for the astronomy students where a growing number of undergraduates extend their senior status over more than one year; by subtracting the fifth-year seniors, we are left with 200 students who are fourth-year astronomy majors.

Table XIII focuses on the most recent enrollment and degree data and compares the contributions from 24 combined departments with those from 40 separate astronomy programs. Despite their reputation for popularity, the introductory astronomy courses, offered by both astronomy and physics departments, register only two-thirds of the number of students enrolled in introductory physics courses.

This report was prepared with the help of Thomas N. Stovall.

Table XIII. Astronomy* enrollments 1989–90 and degrees 1988–89 by type of institution.

	Type of astronomy department	Bachelor's-granting		Master's-granting		Doctoral-granting		Total
		Comb. dep'ts	Sep. dep'ts	Comb. dep'ts	Sep. dep'ts	Comb. dep'ts	Sep. dep'ts	
	Number of dep'ts.	13	7	2	2	9	31	64
Astronomy degrees	Bachelor's	20	16	3	4	8	146	196
	Master's enroute	–	–	4	2	–	71	77
	Terminal master's	–	–	2	2	2	10	16
	Doctor's	–	–	–	–	4	90	94
Astronomy enrollments	Annual intro. enrollments in astronomy dep'ts	8100	2750	2100	1700	4680	46 570	65 900
	Total annual enrollments including intro. astronomy taught in physics dep'ts.	–	–	–	–	–	–	178 900
	Junior astronomy majors	32	14	12	12	18	138	223
	Senior astronomy majors	23	12	5	3	20	138	200
	No. of applicants to grad. programs	–	–	26	17	753	2 639	3 414
	No. of acceptances to grad. programs	–	–	11	10	41	189	258
	First year graduate students	–	–	10	10	12	154	186
	Total graduate enrollment	–	–	22	21	78	721	842

**This survey includes only degree-granting astronomy departments.*